

# **A STUDY ON THE DEVELOPMENT OF THE DEDICATED OBU<sup>1</sup> FOR THE HANDICAPPED PERSONS USING HI-PASS<sup>2</sup> SYSTEM**

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## **ABSTRACT**

This paper presents the development of the dedicated OBU for the handicapped persons using Hi-pass ETC system. The handicapped travelers cannot use the Hi-pass system which is operated unattended because a toll booth operator has to eyewitness the handicapped persons on board for expressway toll discounts. We developed the dedicated OBUs with a biometric sensor to check whether the handicapped persons are on board or not. It was verified that the dedicated OBU works well through several tests of prototype sets.

Key words: OBU, ETCS, Handicapped persons, Biometrics

## **1. INTRODUCTION**

The handicapped persons can get expressway toll discounts on the basis of the Toll Road Act and the Welfare of the Disabled Persons Act. The discount rate is 50% where the conditions for the toll discount are 1) registration of the vehicle, 2) discount card, and 3) handicapped traveler on board. In case of Toll Collection System(TCS) lane with a toll booth operator, he or she can check above three conditions on the

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<sup>1</sup> OBU stands for On Board Unit.

<sup>2</sup> Hi-pass is a registered brand name of ETCS in Korea.

spot. But, under unattended Hi-pass lanes a new method is needed to check it. The dedicated OBU and Hi-pass system can check boarding of the handicapped persons with biometric information. A handicapped traveler with the dedicated OBU stores his/her biometric information in the Biometric Identification Unit(BIU) at local government agency by way of its identification. When he or she uses the Hi-pass lane, toll discount is confirmed by identification of the handicapped person through biometric information. The discount requirements for the handicapped persons in TCS and Hi-pass lanes are listed in table1.

**Table1.** Discount requirements for the handicapped persons in TCS and Hi-pass lanes.

Items	TCS(with operator)	Hi-pass(no operator)
Identification Method	By the operator	By the dedicated OBU and Hi-pass system
Vehicle	Registered Vehicle for the handicapped person	Registered Vehicle for the handicapped person
Confirmation of the handicapped person boarding	Discount card issued by Road Management Office and check by operator	A dedicated OBU with BIU and self-identification
Vehicle Marking	Vehicle Marking for the handicapped person	A dedicated OBU

## 2. DEVELOPMENT OF THE DEDICATED OBU

### 2.1 Configuration of the Hi-pass service system for the handicapped persons

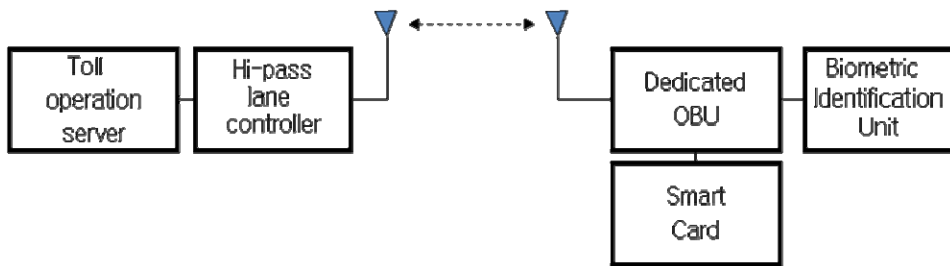
The Hi-pass service for the handicapped persons could be realized with Hi-pass lane system, a dedicated OBU and an enrollment system of bio information. The backend system can generate a special service code for the handicapped person and process charging.

The basic Hi-pass system configuration for the service of the handicapped persons is shown in figure 1(a) and the system is consisted of the following components:

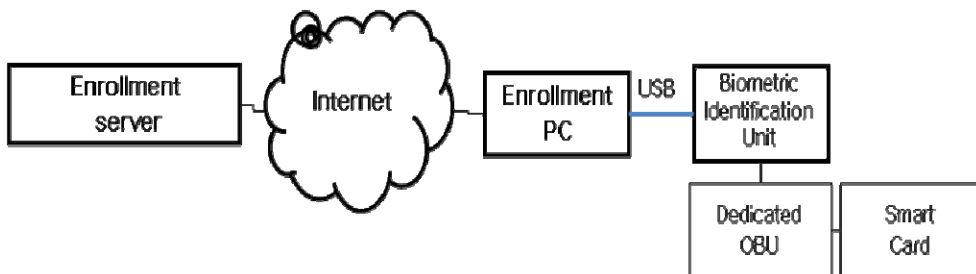
- Toll operation server at toll plaza;
- Hi-pass lane facilities including Hi-pass lane controller, antenna systems, vehicle detection system and camera; [1][2]

- Dedicated OBU for the handicapped persons;
- Bio Identification Unit; [10] and
- Smart card which is inserted to OBU. [1]

Internet based Enrollment system for the storage of bio information that is one of the handicapped person's fingerprint, face, iris and voice, etc., in a BIU is shown in figure 1(b). It is comprised with an enrollment server, enrollment PCs, a dedicated OBU, a BIU and a Smart card. The data between a BIU connected to a dedicated OBU and an enrollment PC are communicated in the encryption pattern.



(a) Hi-pass system configuration for the service of the handicapped persons



(b) Enrollment configuration of storing bio information into a BIU

Figure1. Hi-pass system configuration of a dedicated OBU for the handicapped persons.

A fingerprint sensor is used in the first phase development of the dedicated OBUs. Other technologies such as face, iris and voice recognition will be applied to the dedicated OBU later development phase.

## 2.2 Block diagram of a dedicated OBU for the handicapped persons

Figure 2 shows the block diagram of a dedicated OBU for the handicapped persons. The basic configuration of a dedicated OBU is comprised of the following parts:

- 5.8GHz RF/ 850nm IR Dedicated Short Range Communication (DSRC) module; [7][8][9]
- 32Mbits flash memory and 8Mbits SDRAM in OBU;
- Man-machine interface module for speaker, buttons, LCD/LED ;
- ARM 7 core based CPU for OBU;
- USB controller;
- Smart Card controller;
- 8Mbytes flash memory and 8Mbytes SDRAM in BIU;
- Finger printer sensor for bio information; [10]
- I/O module for checking bio information enrollment, deletion and identification; and
- ARM 9 core based CPU for BIU. [10]

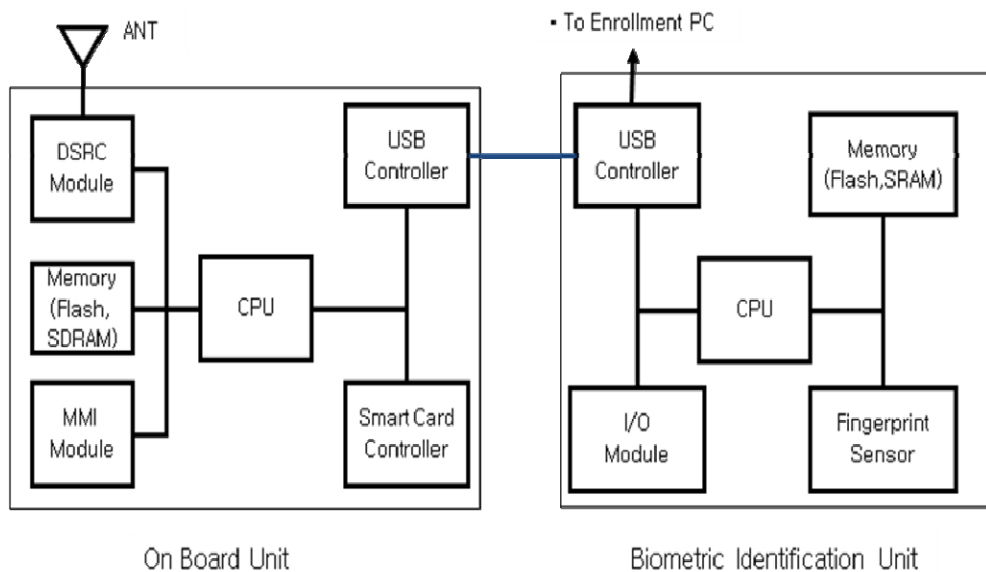


Figure2. Block diagram of a dedicated OBU. [2][10]

The detailed specifications of a dedicated OBU and a BIU are shown in table 2 and 3. Hi-pass system use two types of carrier: 1) radio frequency; 2) infra red. [7][8][9]

**Table2.** Specifications of On Board Unit. [2][4]

Type	Specifications	
RF Carrier	Carrier Frequency	5.8 GHz
	Tx power	10 dBm
	Band width	10MHz
	Modulation	ASK
	Bit rate	1,024 Mbps
	Channel	1 CH
	Input Voltage	DC 12V~24V
	Receiver Sensitivity	Max -85dBm
	OBU ANT Gain	8dBi
IR Carrier	Carrier Wavelength	TX : 854.23nm / RX : 830.5~899.53nm
	Tx power	1.756~1.834w/sr
	Receiver Sensitivity	69.91~69.81mW/m <sup>2</sup>
	Modulation	ASK-OOK
	Input Voltage	DC 12V~24V

**Table3.** Specifications of Bio Identification Unit. [10]

Items	Specifications	
Bio Information Processing Module	CPU	ARM 9core, 200MHz, 32bit RISC
	SDRAM	8M bytes
	Flash ROM	1M bytes
	Capture speed	200 ms
	Verification speed	Less than 1 second
	FAR	0.001%
	FRR	0.1%
	Bio data encryption	256 bit key(AES)
	Bit rates	9,600 ~ 115,200 bps
	Supply Voltage	3 ~ 5 Volts
	Image size(pixel)	152[width] x 200[height]
	Image size(pixel)	152[width] x 200[height]
Finger Printer Sensor	Sensing Area(mm)	10.64[width] x 14.00[height]
	Resolution	363 dpi
	Image format	256 gray levels
	Interface	sensing SPI

### 3. BIO INFORMATION ENROLLMENT PROCEDURE AND TOLL DISCOUNT OPERATION

#### 3.1 Bio information enrollment procedure

The encrypted data communication between an enrollment PC and a BIU is shown in the block diagram of figure 3 for the fingerprint enrollment procedure. For the prevention of misusing the fingerprint information, the encryption keys are generated by using the private keys. All fingerprint information is encrypted and stored only in the BIU which the user holds. Host random key of 64bits, serial number of 128bits, command data of 64bits are used in the encrypted data communication between an enrollment PC and a BIU.

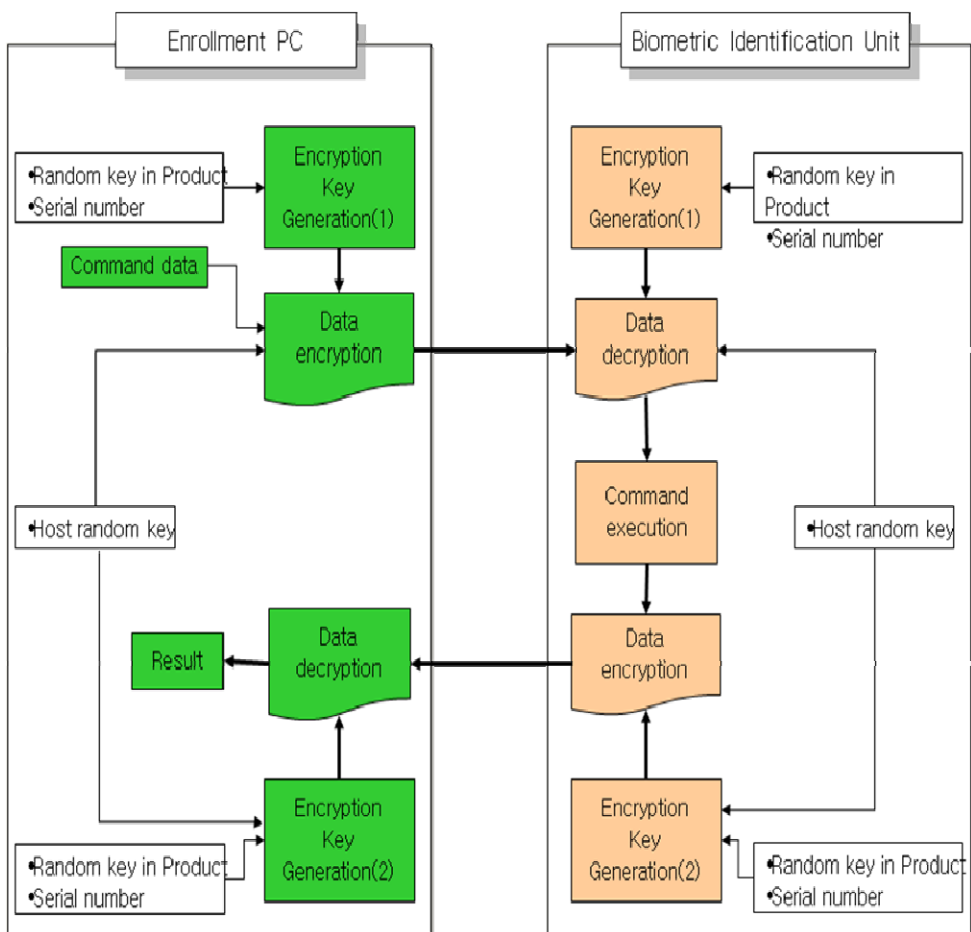


Figure3. Encrypted data communication between a BIU and an enrollment system. [10]

A BIU is designed to store up to 16 fingerprints or up to 4 handicapped persons' 4 fingerprints each. Figure 4 shows the user enrollment procedure of the BIU which was bought by a handicapped person. Only the authorized personnel can operate the enrollment PC which is connected to the BIU and communicates with the internet based enrollment server described in figure 1. Fingerprint image is captured two times by the authorized personnel. And the captured images are compared with each other. If two images are matched exactly, the user's fingerprint database is saved in the specific place of the BIU and the enrollment procedure is finished.

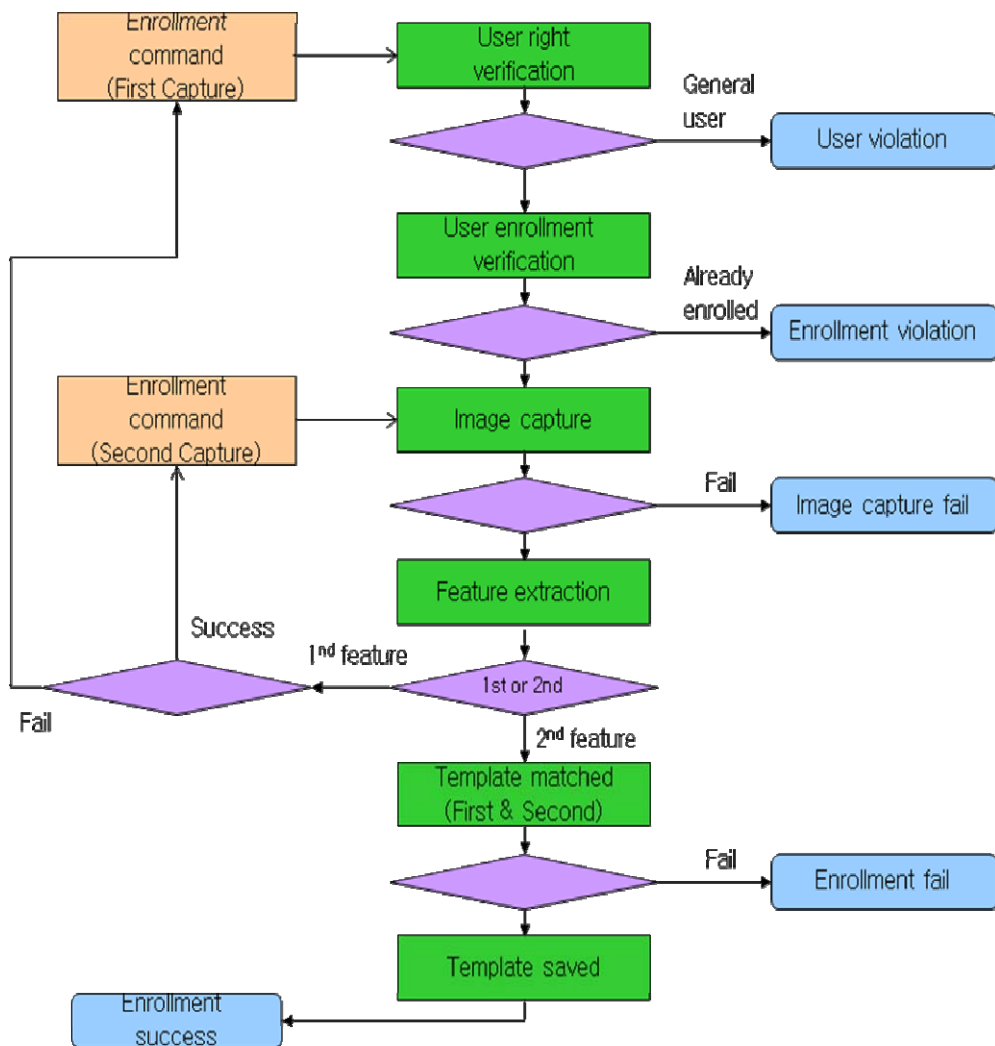


Figure 4. The user enrollment procedure of the BIU. [10]

### 3.2 Toll discount operation

The operational procedure of the dedicated OBU for the handicapped persons is shown in figure 5. On the booting stage the user has to identify his or her fingerprint over the fingerprint sensor of the BIU as a guidance of OBU. If the verification is successful, the OBU will be set to 50% discount mode, otherwise to normal mode. Once the OBU passed the Hi-pass lane and be charged, it will return to normal mode. So, continual authentication procedures are needed for the next discount operations. This procedure can prevent illegal usages such as fraudulent identification.

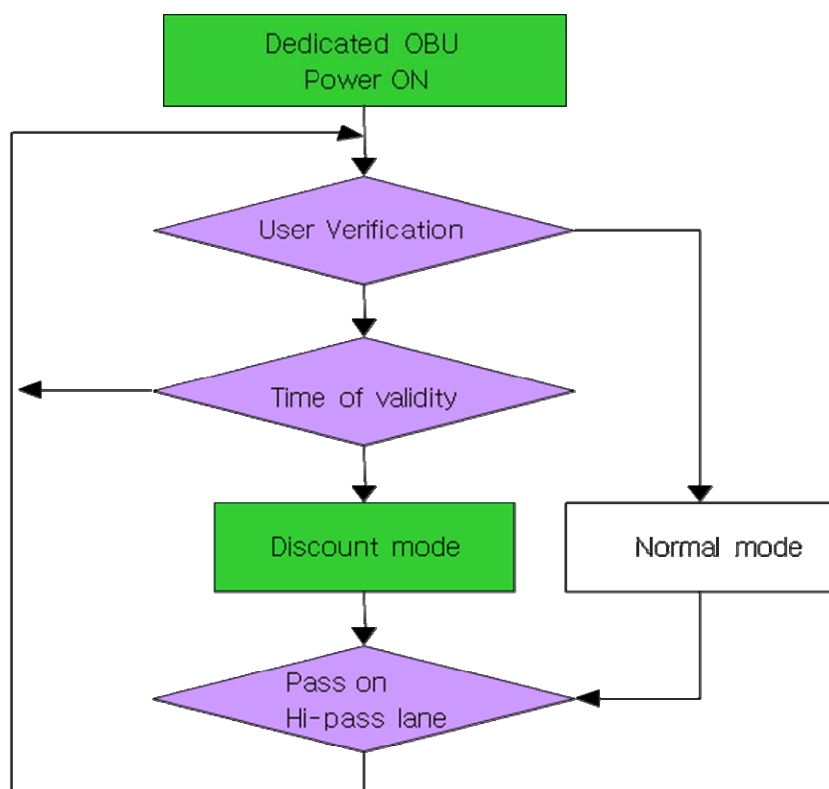


Figure5. User verification procedure of the dedicated OBU. [10]



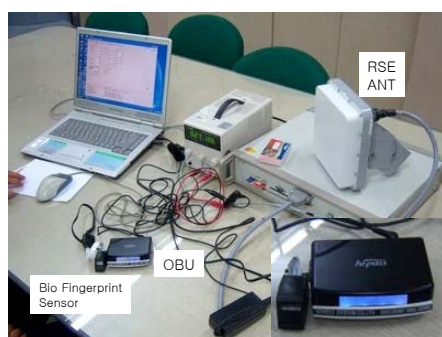
#### 4. TEST RESULTS OF THE DEDICATED OBU

In the development of the dedicated OBUs for the handicapped persons, Korea Expressway Corporation(KEC) and five development groups were participated. KEC is in charge of the development with upgrading Hi-pass system, developing a bio information enrollment system and taking a main role to make all the specifications related to the function. And five development groups take a part of making prototype sets for test and producing samples of the dedicated OBU.

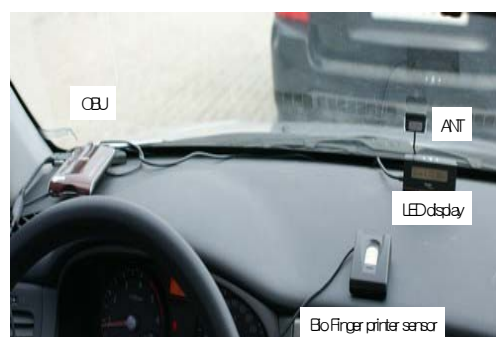
From February to May 2009 the prototype sets of the dedicated OBU were evaluated by KEC. The test procedure was based on the standard rules of the OBU test. The test results of the fingerprint enrollment and the toll discount operation were described in table 4. The accuracy of the BIU is defined to be that FAR is less than 0.001% and FRR is less than 0.1%. The verification time between a dedicated OBU and a BIU is less than 1 second. Figure 6 shows the test configuration of the dedicated OBU which were performed in the OBU laboratory and the test road. [3][5][6]

**Table4.** Test results of the dedicated OBU on the prototype sets.

Development group	Carrier type	Sensor type	Enrollment test	Discount operation test
Jung-Lip Electronics	RF	Electronic	Pass	Pass
Kospace	RF	Optical	Pass	Pass
Seoul Commtech	RF	Electronic	Pass	Pass
Mugunghwa Electronics	IR	Swipe	Pass	Pass
Vehicle System	RF	Optical	Pass	Pass



(a) Laboratory test



(b) Field test

Figure 6. Operation and performance test of a dedicated OBU.

## **5. CONCLUSIONS AND FUTURE WORKS**

As a result for the development and the test of the dedicated OBU for the handicapped persons, the operation was successful. Through the development of the dedicated OBU, the handicapped can utilize the Hi-pass system on a toll discounted basis and also can improve their transport welfare.

The toll road operators such as KEC can prevent the fraud usage of discount program by authenticating the board of the handicapped systematically.

This time the fingerprint recognition has been adopted for the biometric sensor of the BIU. In future other biometric pattern recognition technologies such as face, voice and iris, etc., will be applied to enhance the usability of the dedicated OBU for the handicapped.

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